

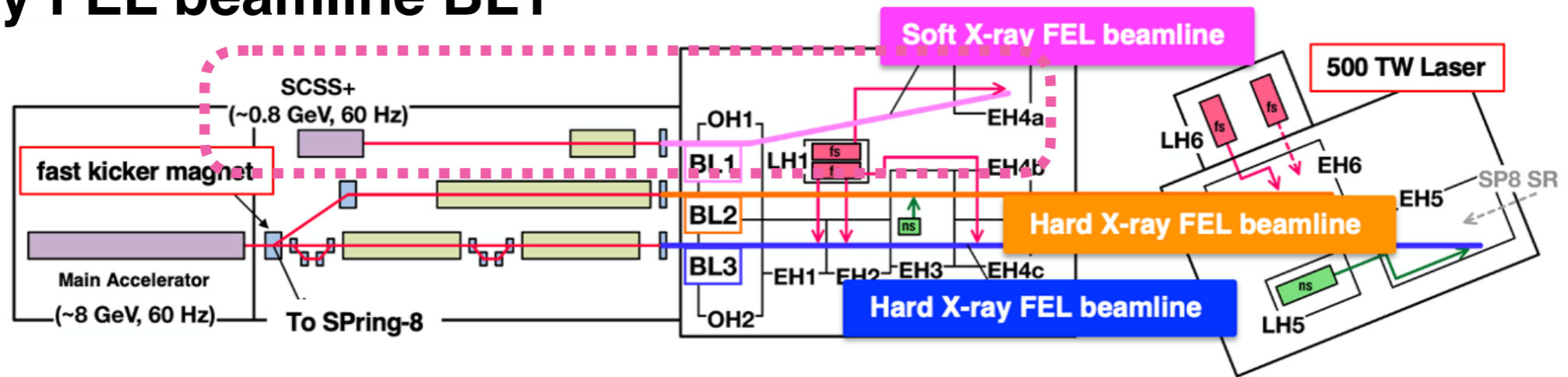
# **Technical Updates**

## **Soft X-ray FEL beamline (BL1)**

SACLA Users' Meeting 2023  
Shigeki Owada  
on behalf of SACLA beamline staff

# Introduction

## Soft X-ray FEL beamline BL1

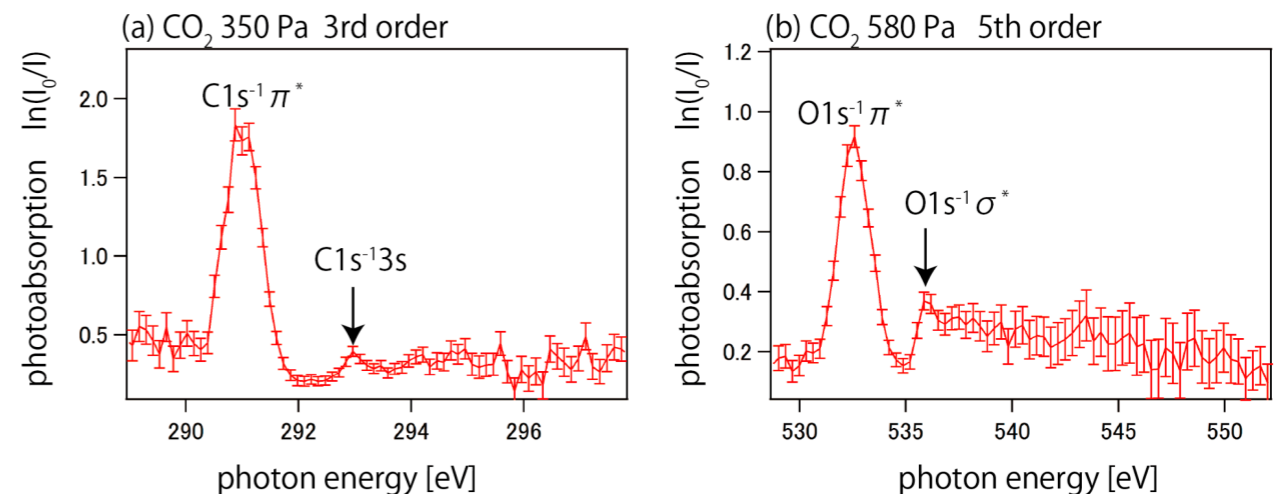


## Typical operation status

Photon energy	40 - 150 eV (optional: <40 eV)
Pulse duration	~30 fs (averaged)
Band width	~10 <sup>-2</sup>
Pulse energy	~50 μJ @ 100 eV
Photon number	~ 3×10 <sup>12</sup> photons/pulse
Repetition rate	60 Hz

## Utilization of harmonics

- Typical pulse energy of 3rd harmonics <100 nJ/pulse @ 240 eV, 0.2 μm Sn foil
- 5th harmonics is available for spectroscopy.



H. Iwayama, *Appl. Sci.*, 10, 7852(2020).

# Topics

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- **Introduction**

- **New SX-FEL instruments**

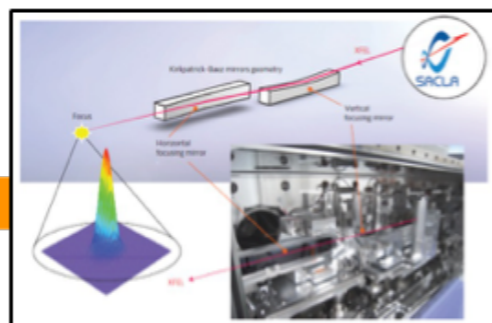
**Soft X-ray sub- $\mu\text{m}$  focusing system**

**Soft X-ray spectrometer**

# Evolution of focusing systems at BL1

- **KB mirror system**

**μm focusing**

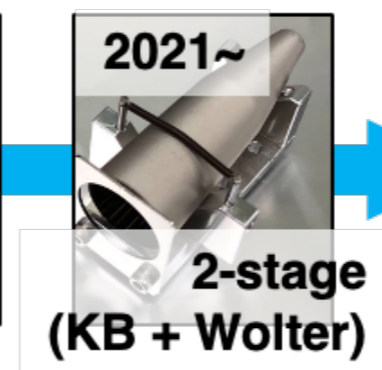


**~4 μm**  
**~10<sup>15</sup> W/cm<sup>2</sup>**

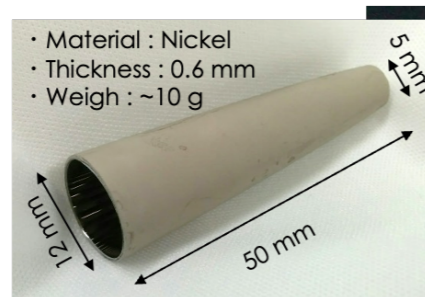
- **Two-stage focusing system**

SACLA Basic development program, Prof. Mimura, Prof Kimura  
=> "SACLA Basic Development Program 2022" Dr. S. Egawa

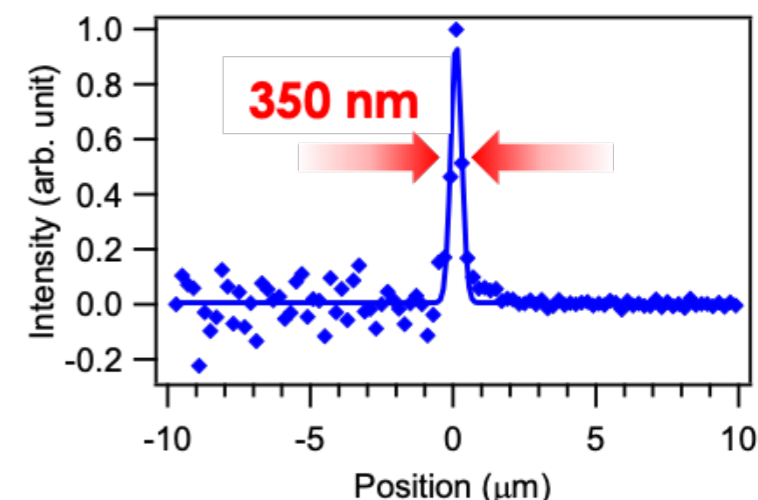
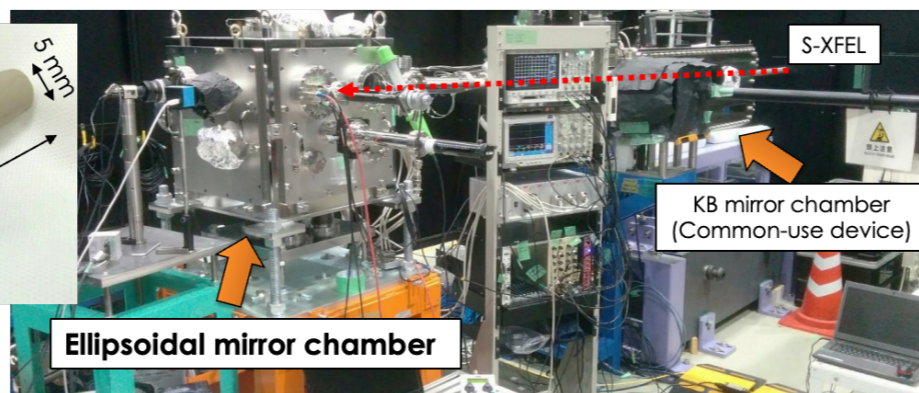
**Sub-μm focusing**



**~0.3 μm**  
**10<sup>16</sup>~10<sup>17</sup> Wcm<sup>2</sup>**

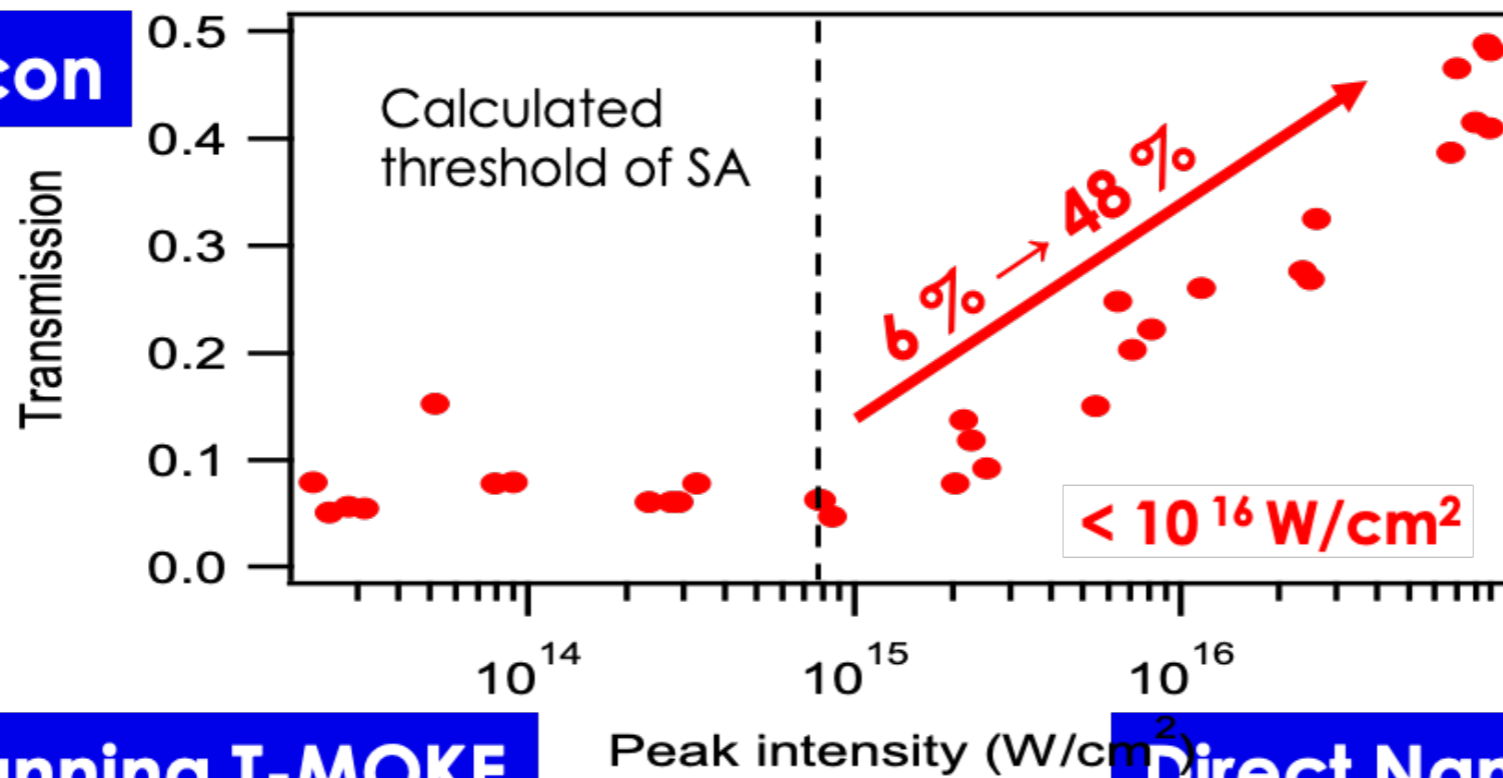


- Material : Nickel
- Thickness : 0.6 mm
- Weigh : ~10 g

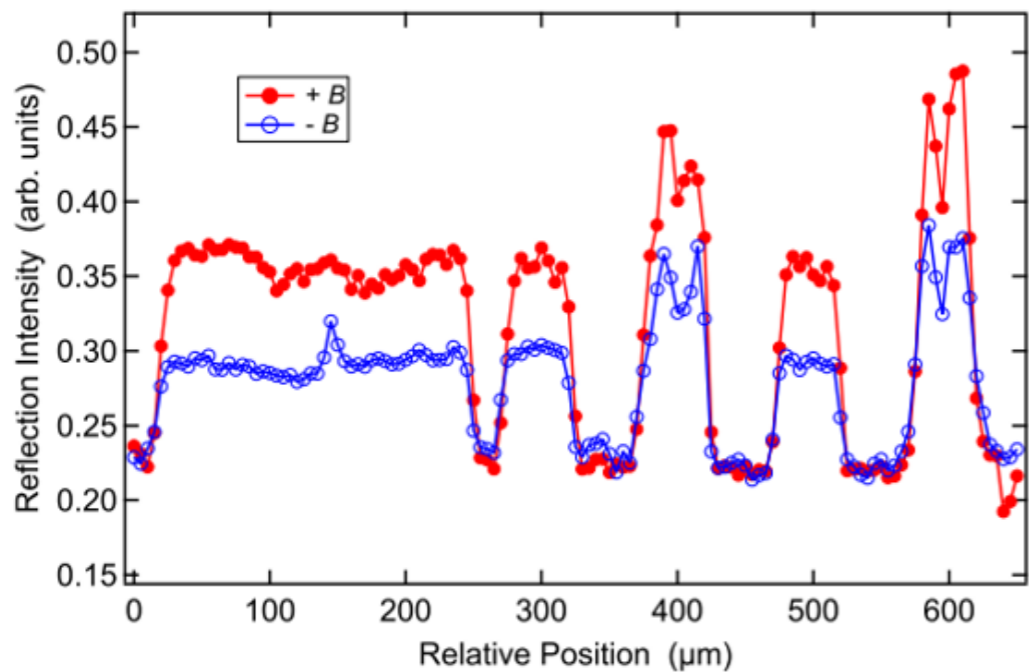


# Applications

## SA in silicon

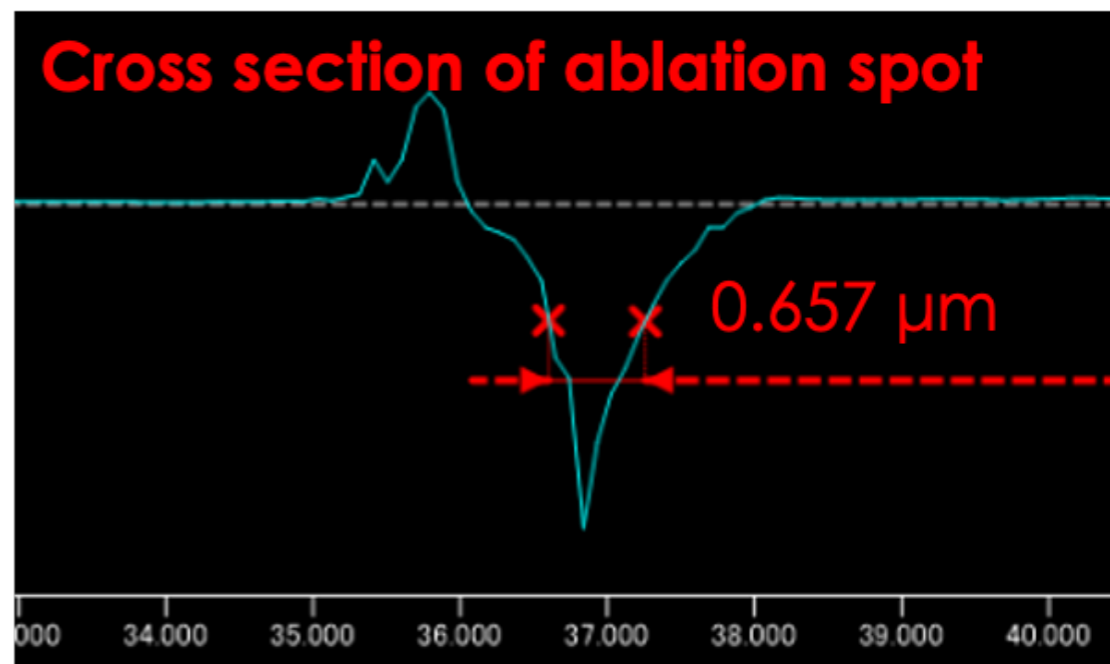


## Scanning T-MOKE



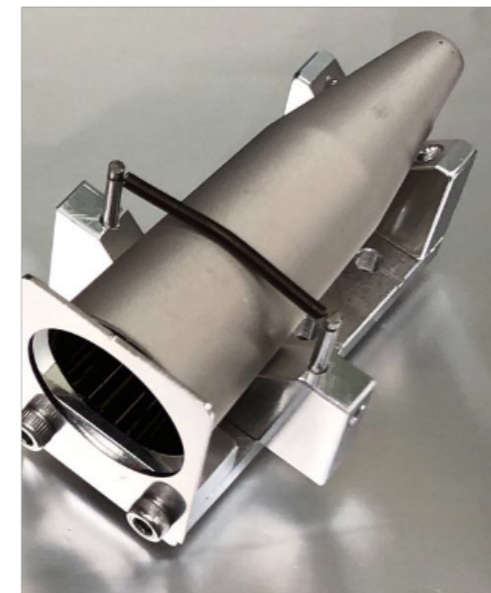
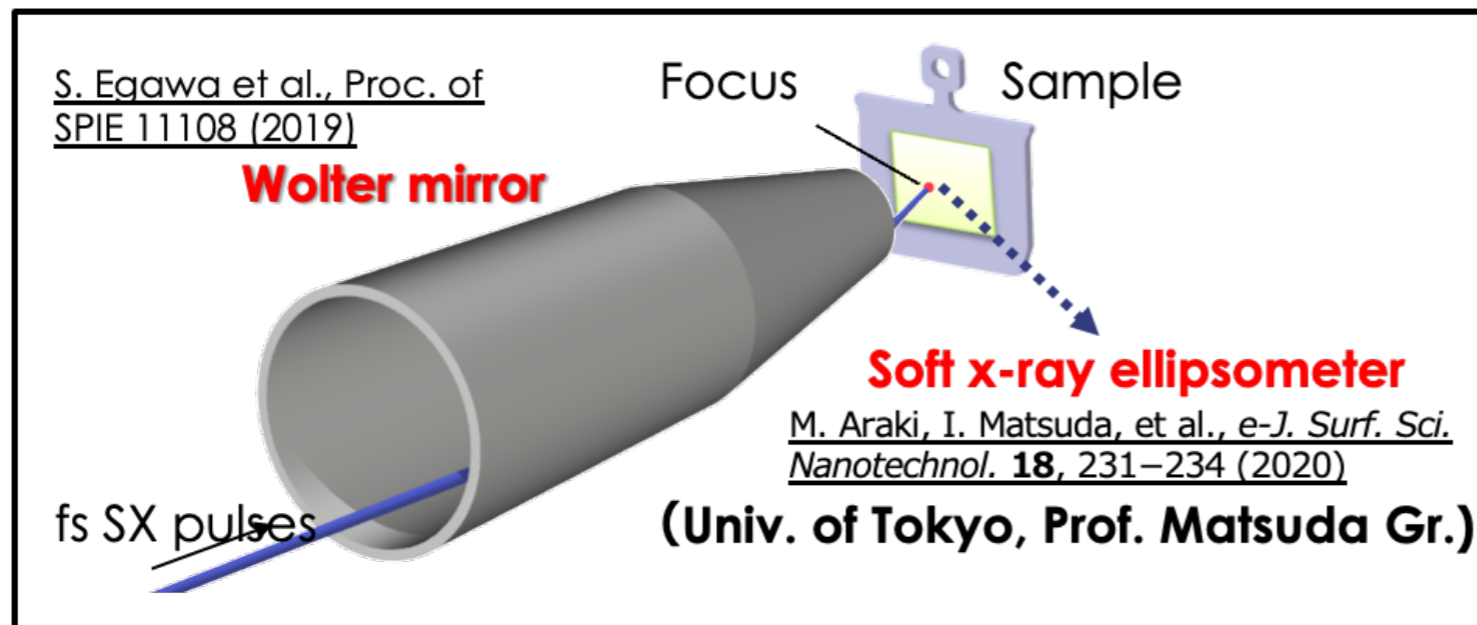
Y. Kubota, et al., Appl. Phys. Lett., **117**, 042405 (2019)

## Direct Nano-scale processing

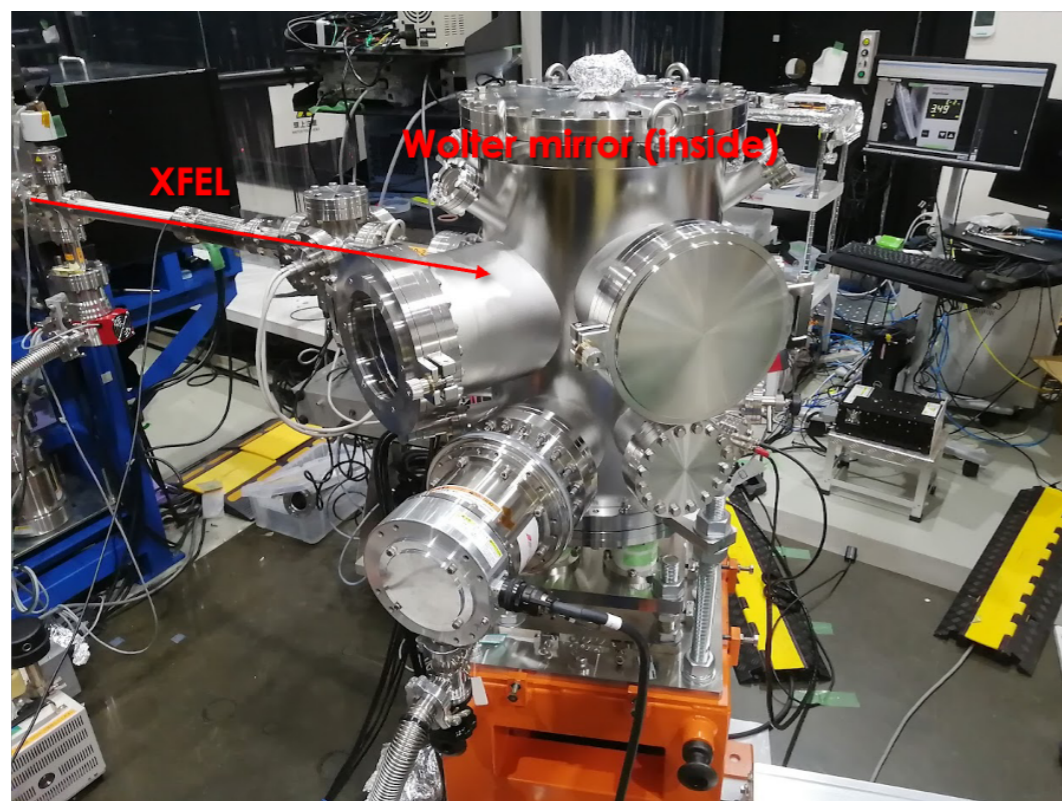


Courtesy of **Dr. Sakaue** (Tokyo Univ.)

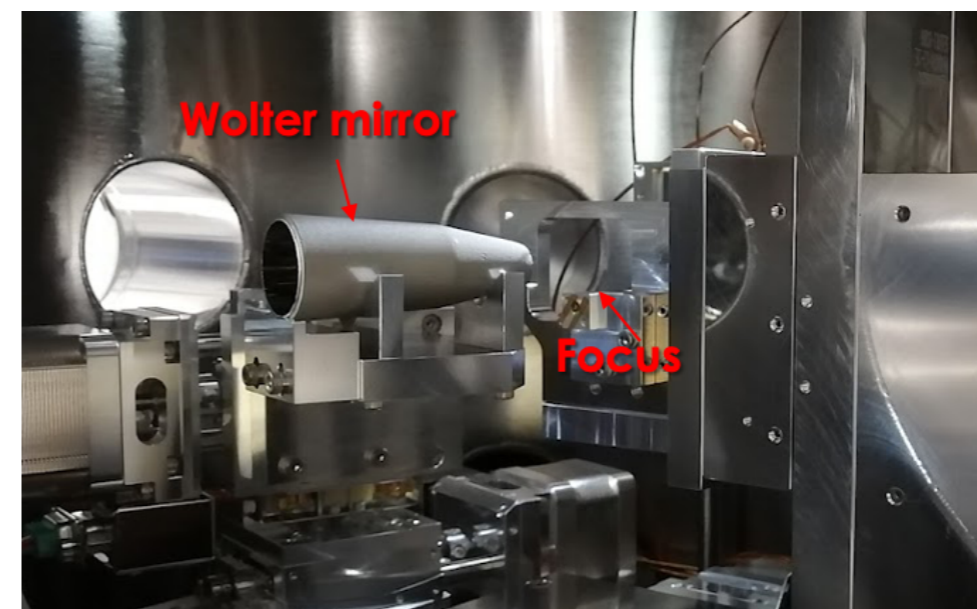
# Experimental platform for sub- $\mu\text{m}$ beam



Wolter mirror satisfy the Abbe's sine condition  
→ **Sub-micron SXFEL beam with relaxed alignment difficulty**



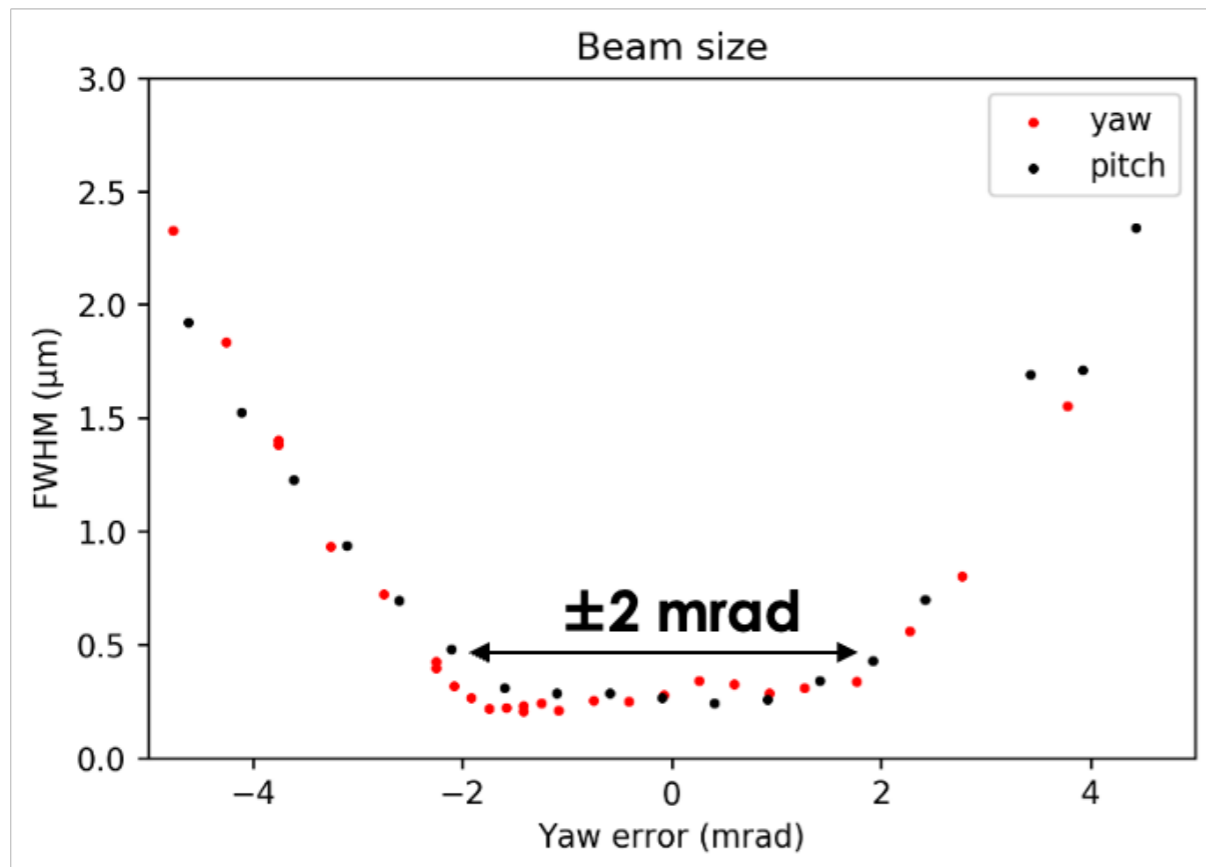
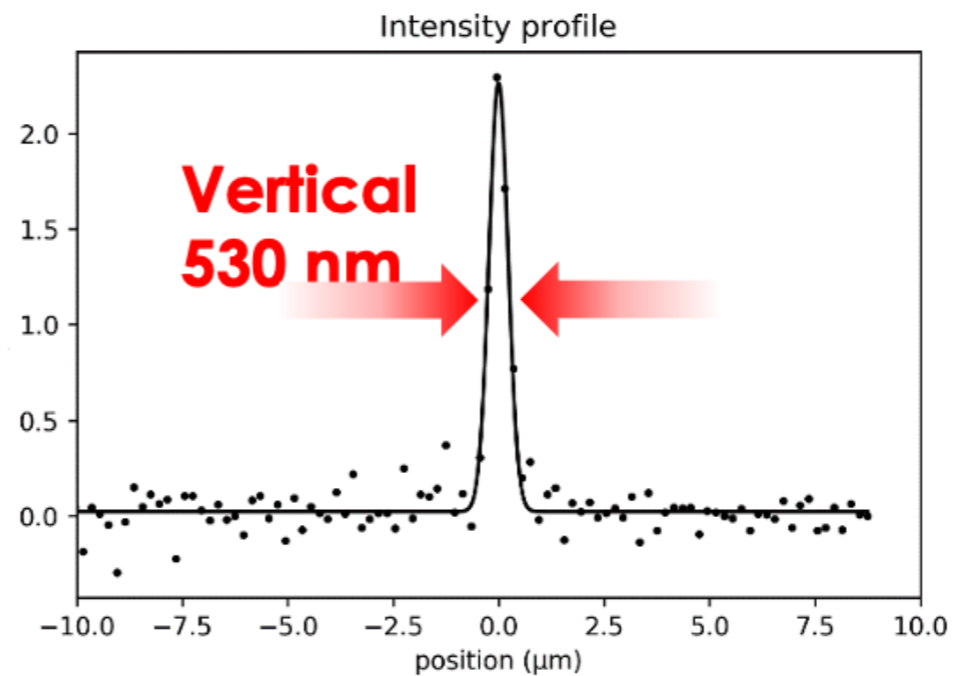
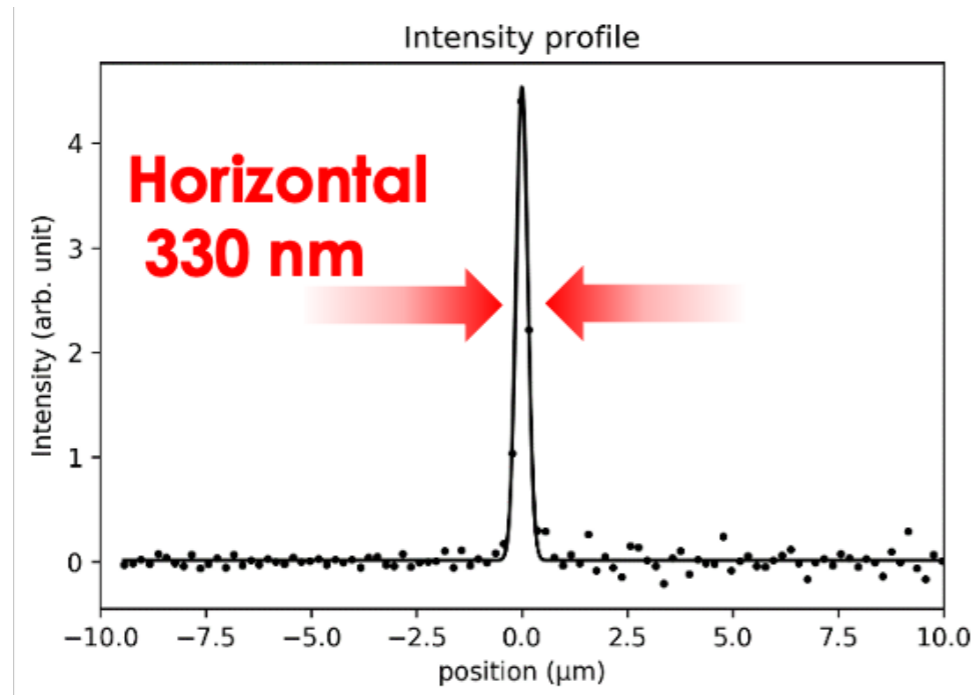
↑ **Dedicated chamber**



↑ **Mirror**

SACLA Basic development program  
Prof. Mimura, Prof. Matsuda

# Beam characteristics



↑ **Sub-micron beam produced**

← **Large angular acceptance confirmed**

- **General purpose experimental system is open for users (FY2022~)**
- **Pump-Probe type platform is in development. (~FY2023)**
- **Optical laser is focused by the Wolter mirror.**

# Topics

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- **Introduction**
- **New SX-FEL instruments**

**Soft X-ray sub- $\mu\text{m}$  focusing system**

**Soft X-ray spectrometer**



# Soft X-ray Spectrometer

=> “SACLA Basic Development Program 2022” Dr. H. Iwayama

- Flat-field grazing angle spectrometer(XUV639, Shinku-kogaku)  
Grating 600 lines/mm → 1200 lines/mm

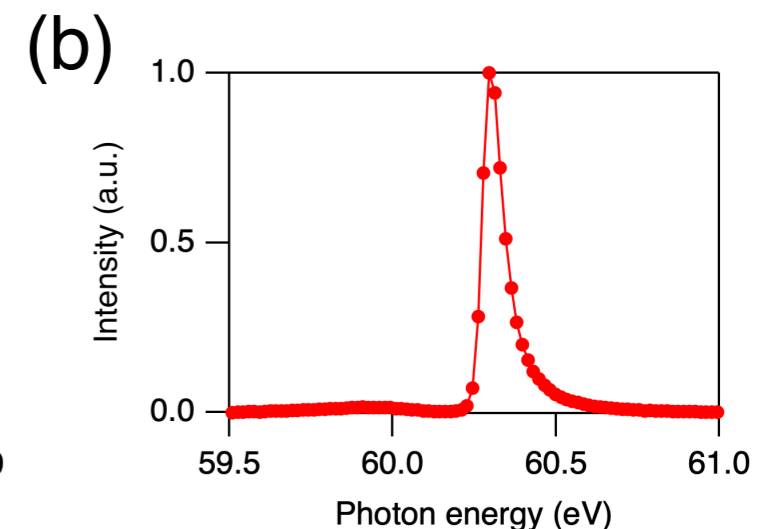
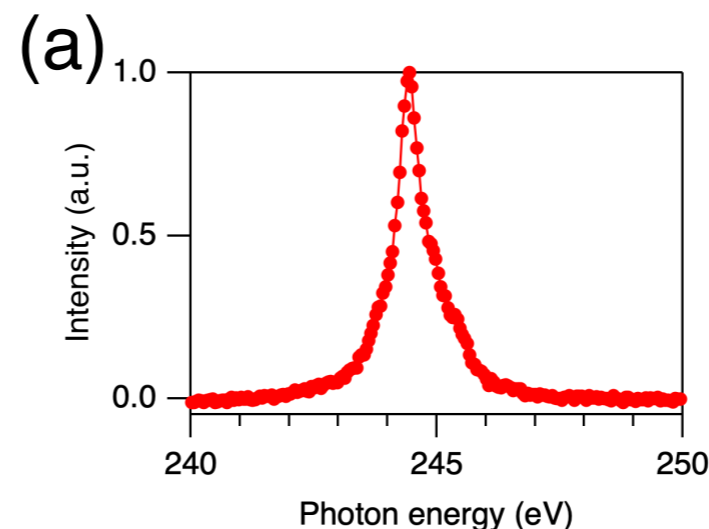
- Detector            Back-illuminated CCD (DO940P-BEN, Andor)



- Pixel size            13.5  $\mu\text{m}$   $\times$  13.5  $\mu\text{m}$
- Rep. rate            60 Hz (1D binning mode)
- Data storage        HPC system (in FY2023)

- Sample spectra

- (a) Absorption of Ar 2p→4s  
(3rd harmonics of  $\sim 81.5$  eV)
- (b) Transmission of He gas cell  
as a bandpass filter  
(fundamental at  $\sim 60.1$  eV)



J. Harries, *J. Phys. B*, 46, 164021 (2013).

# Summary

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- **Sub- $\mu\text{m}$  focusing system is upgraded.**
- **Soft X-ray spectrometer is developed.**
- **We will keep upgrading BL instruments, experimental platforms.**